COPING WITH COLD

Frank Lane Picture Agency

Cameron McNeish/Mountain Camera

- WARNING NETWORKS
- WATERPROOFS
- SNOW BUSINESS

MACHINES AND MATERIALS come to the rescue when the weather gets too hot, too wet or too cold. A great deal of effort goes into dealing with the effects of cold weather in particular, as snow and ice can severely disrupt both travel and communications.

Keeping wintry roads clear is a sophisticated and well-organized business involving salting trucks, snow ploughs, snow blowers and, in some areas, computer-controlled warning networks that include electronic roadside monitoring stations.

Snow busters

In areas that have more than their fair share of snow, a salt and grit mixture is used to keep the roads clear. Salted water freezes at a considerably lower temperature than salt-free water, so salting snow makes it melt and drain away. If the temperature were to drop dramatically after salting, however, the melted snow would turn into sheet ice. Using grit in conjunction with the salt prevents this from happening.

Gritting machines can be mounted on lorries or towed behind vehicles, and fleets of these are used to deliver a measured dose of salt and grit.

Trucks can also be fitted with snow ploughs for road clearing and farmers are sometimes called on to mount snow ploughs on tractors to deal with snow drifts of up to two metres. Snow blowers with turbocharged diesel engines can be mounted on mechnanical diggers to cope with snowdrifts up to five metres deep.

In some weather-monitoring networks there are roadside sensors that can measure air temperature, road temperature, soil temperature,

***Prolonged exposure** to wet and cold can cause hypothermia. A waterproof sleeping-bag keeps the body warm and dry. A mix of salt and grit helps to keep roads open (top). As salt melts the snow, grit prevents it from re-freezing.*

wind speed and direction, as well as the salinity of water on the road. The sensors are linked by telephone lines to a computer system. The computer system receives information from a central weather centre and has a sophisticated programme of its own to assess the need for salting all, or just certain, key roads that are at risk from ice or snow.

Keeping snug

In wintry weather, clothing made with thick insulating materials is ideal. Perhaps the best of these is down, particularly that of the Eider duck. If the garment is designed properly so that there are no thin patches, then down – worn with several other layers of clothing – can keep out the worst cold, including that found at the north and south poles. Any other fabric or material that traps small pockets of heat close to the body will make a good insulator against the cold.

Another heat-retaining material is the thin, shiny, metallic, reinforced fabric popularly known as the 'space blanket'. This does not stop air from escaping, but retains radiated heat by reflecting it back.

Modern fabrics are designed to keep rain out and let perspiration out too, cutting down on the 'wet inside' feeling from non-permeable coverings such as rubber and polyvinyl chloride (PVC). Waterproof fabrics such as Gore-tex are made up of an outer fabric above a lining material over a membrane that has nearly 10 billion tiny holes, or pores, in every 6.5 sq cm of material. Each pore is about 20,000 times smaller than a raindrop, but 700 times larger than a water vapour molecule produced by perspiration. Thus, water produced within can get out – but rain or melted snow cannot get in.

***The armed forces** are kitted out to cope with weather extremes. Uniforms, made of Gore-tex, allow for sufficient ventilation to deal with perspiration, but prevent any rain seeping through to the wearer's skin.*

E. Nevill/TRH

***Snow blowing** machines are used to clear minor roads in outlying areas which have insufficient access for the larger snowploughs. These machines are part of a specialized fleet of equipment.*

John Cleare/Mountain Camera

HYPOTHERMIA – THE VITAL SIGNS

Long immersion in cold water, wearing wet clothes at high altitudes and general exposure to cold in an unheated or badly heated house for a long time can all induce hypothermia.

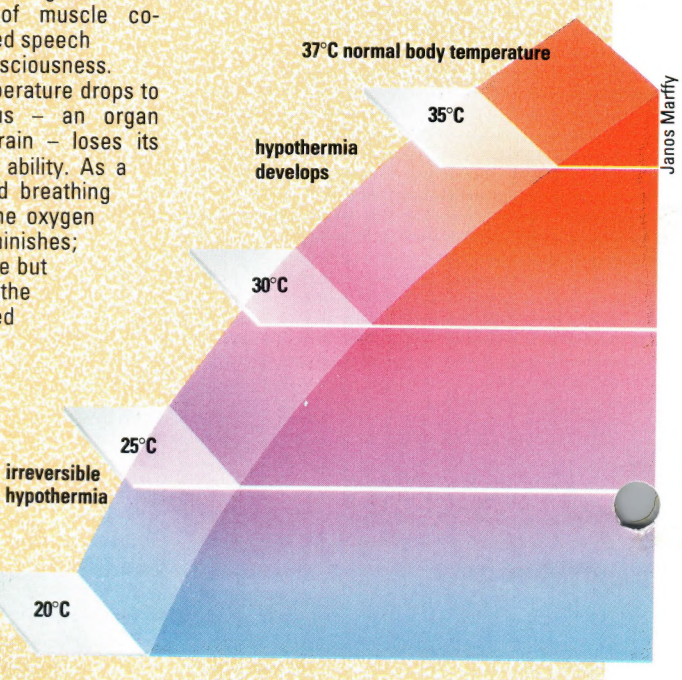
When the body temperature starts to drop below the normal 37°C the victim progressively:

- complains of feeling miserably cold
- feels abnormally cold to the touch
- starts to shiver uncontrollably
- stops shivering and begins to experience a lack of muscle co-ordination and slurred speech
- eventually loses consciousness.

When the body temperature drops to 30°C, the hypothalmus – an organ situated below the brain – loses its temperature-regulating ability. As a result, cell activity and breathing rate slow down and the oxygen supply to the brain diminishes; the heart muscles ripple but do not pump blood. If the victim is not hospitalized at this point, he or she will undoubtedly die.

When dealing with a conscious hypothermia victim:

- replace wet clothing with dry garments
- wrap them in a blanket, but do not cover their face
- do not rub or massage them
- do not give them alcohol
- never place their hands or arms in direct contact with their body.

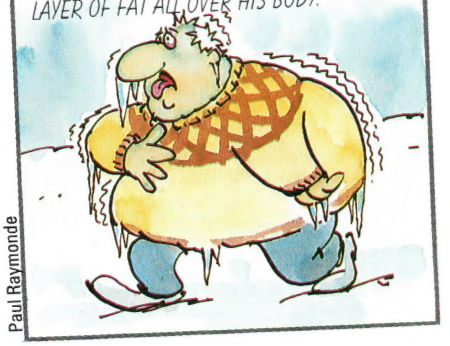


Janos Marffy

Just amazing!

FAT WONDER

A 125 KG ICELANDER SPENT SIX HOURS IN ICY WATER, THEN WALKED FOR THREE HOURS OVER A FROZEN LAVA FIELD WEARING ONLY JEANS, A SHIRT AND A SWEATER. HE WAS SAVED BY THE 14 MM LAYER OF FAT ALL OVER HIS BODY.



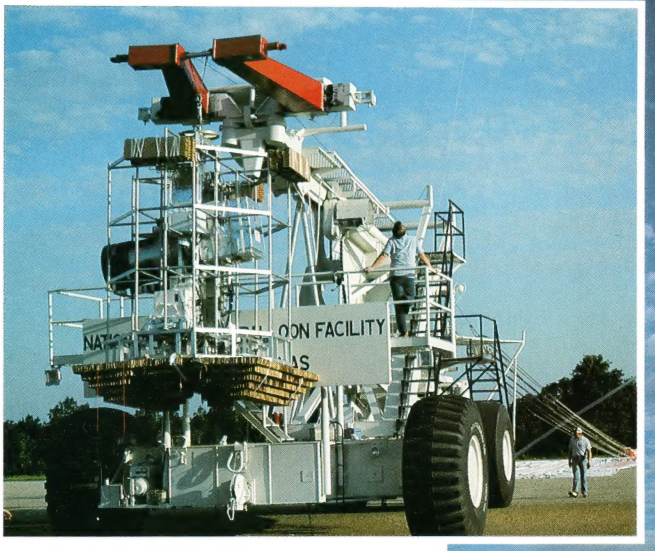
Paul Raymonde

- JET STREAM WINDS
- WEATHER BUOYS
- NUMBER CRUNCHERS

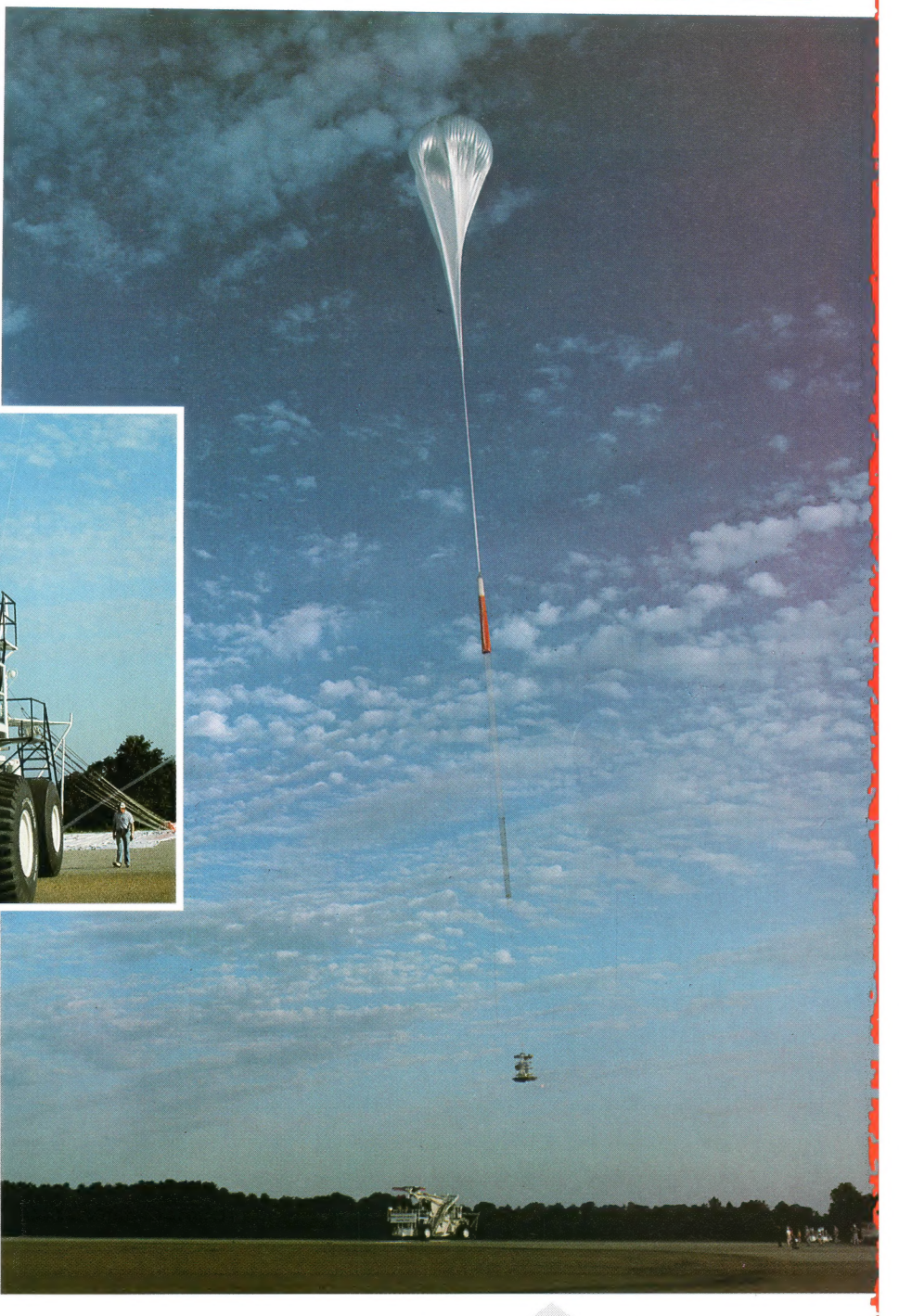
FORECASTING

POWERFUL NEW TOOLS available to meteorologists enable them to produce more and more accurate predictions. Reliable forecasts can now be made for 24 hours ahead, and work is underway to refine the long range forecasts that look up to a month ahead.

All this effort is not just to make sure that you choose a sunny day for your picnic. It is a matter of life, death, or large sums of money for all sorts of people. These include not only fishermen and sea captains wondering whether or not to put to sea, but also airline pilots and farmers who want a fine, settled period of weather to sow and harvest their crops. Even ice cream makers vary the number of cornets they make according to the weather forecast.



Telegraph Colour Library



***Radiosonde balloons** are launched from airfields using a large trailer (inset). The balloon carries instruments and a radio that parachute back to Earth.*

Before meteorologists can make a forecast, they need to have an extremely accurate picture of what the weather is doing over as large an area as possible. So weather observations are collected from:

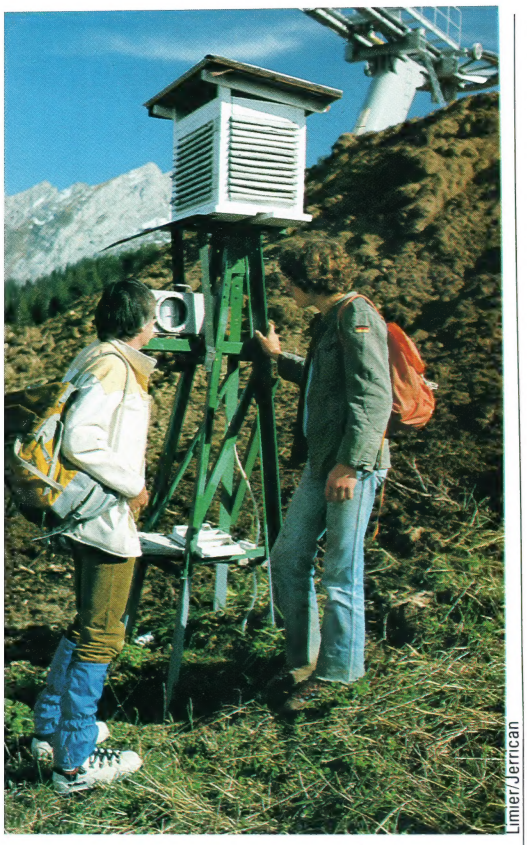
- ground stations
- stratospheric weather balloons
- a countrywide radar network
- polar-orbiting and geostationary satellites
- oil rigs and automatic buoys
- civilian aircraft and ships
- special weather flights.

Synoptic observations

All levels of the atmosphere must be observed because a shift in the upper atmosphere winds of 2,000 km can trigger a radical change in the weather. That upper atmosphere change might, in turn, be a reaction to a weather event in the opposite hemisphere two or three days previously. So weather information must be collected all round the world to give a complete picture.

The accuracy and type of observations made are crucial, as well as the time when they are made. In order to get a snapshot of what is going on at any one instant, observations are made synoptically. This means that they are taken at the same time worldwide, with the main observations coming at 00.00, 06.00, 12.00 and 18.00 Co-ordinated Universal Time (UTC) or, as it is otherwise known, Greenwich Mean Time (GMT). The data are then sent via communications satellite, land line or radio to one or all of the world's meteorological centres.

At a ground station, a trained observer measures wind speed and



Lmier/Jerrican

Most ground stations *have a louvred enclosure that shelters the instruments without cutting them off from the weather phenomena that they measure.*

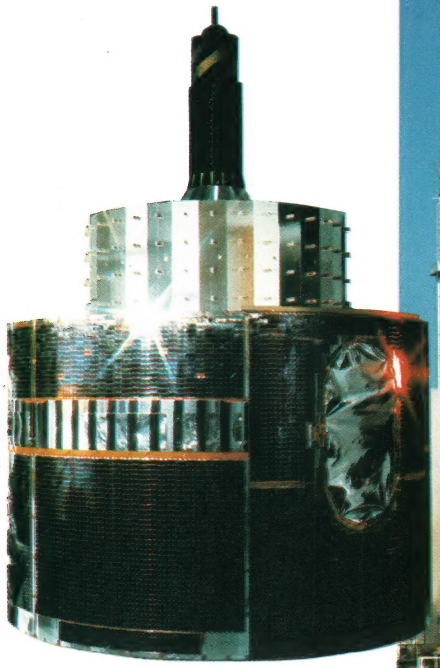
direction, as well as visibility, atmospheric pressure, air temperature and dew point temperature. (See Elements in Action, Planet Earth, pages 29–32 for information on dew point.) The observer also reports cloud types and amounts, and general weather conditions. He or she also measures the amount of rainfall, hours of sunshine and temperature maximums and minimums on a daily basis.

Despite their name, ground stations can also be on water – around the world there are thousands of stations all making identical weather reports. For example, in the British Isles alone, there are about 65 weather stations that report back every hour of the day and night to the British Meteorological Office Headquarters at Bracknell, Berkshire. Another 35 or so weather stations report back every hour during daylight.

Weather ships

Weather forecasters used to rely on weather ships for mid-ocean observations, which are very important because this is where many weather systems are born. These are now being replaced by automatic buoys. The buoys transmit weather data back to a data collection station on land. There is also a moving network of about 7,000 merchant ships that carry meteorological apparatus and report back. Of these ships, about 2,500 send their reports to Bracknell.

Meteosat geostationary *weather satellites (below) are launched on Ariane rockets from Kourou in French Guiana. Each one covers a fifth of the globe, so five are constantly on station to provide worldwide coverage.*



ESA

Useful as all the observations taken at surface level are, they must be complemented by measurements of weather conditions higher up in the atmosphere. This is where balloons (called radiosondes) come in. Around the world there is a network of stations where helium- or hydrogen-filled instrument carrying balloons are released every six or 12 hours.

The balloons rise 15 km in the air before they burst. The instruments measure pressure, temperature and humidity at frequent intervals during the ascent, and transmit the data to a ground station or satellite, which then relays it to Earth.

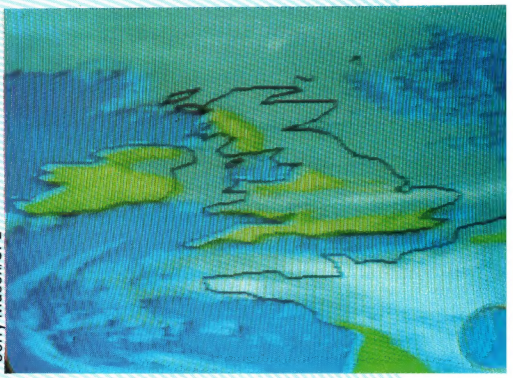
The wind speed and direction are determined by radar tracking of the balloon as it climbs. From launch to maximum height takes about an hour. There are not as many balloon-launching stations as the meteorologists would like – they are expensive to maintain – especially in the oceans.

An alternative scheme called the Automated Shipboard Aerological System (ASAP) is already being employed. Merchants ships launch balloons that transmit their data direct to a satellite that relays it to a ground station. The balloon's movements after launch and, therefore, the wind direction and speed are tracked using a satellite navigation system.

Aircraft

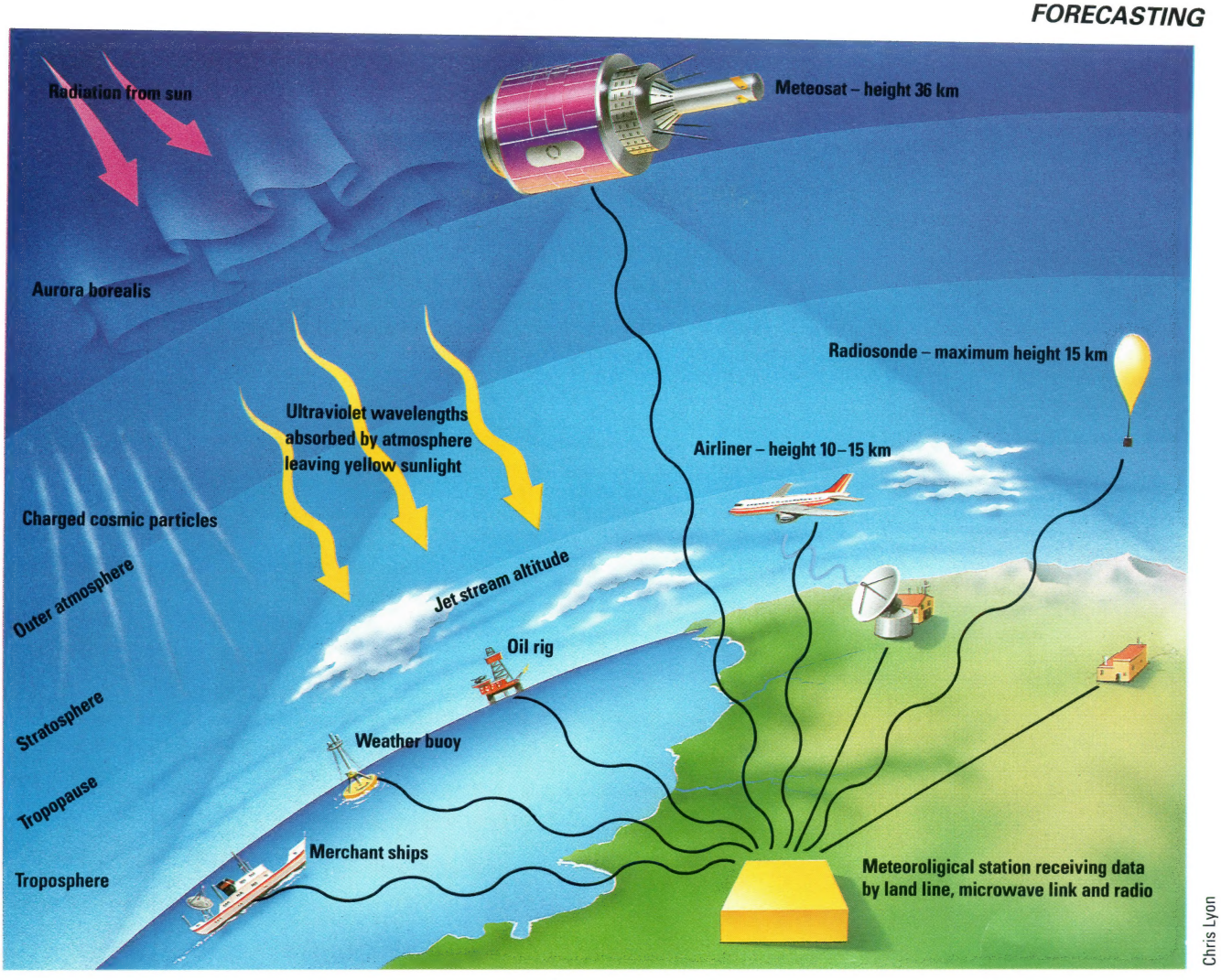
Jet airliners fly at a height of 10-13 km, which is one of the most important levels of the atmosphere.

TV WEATHER MAPS

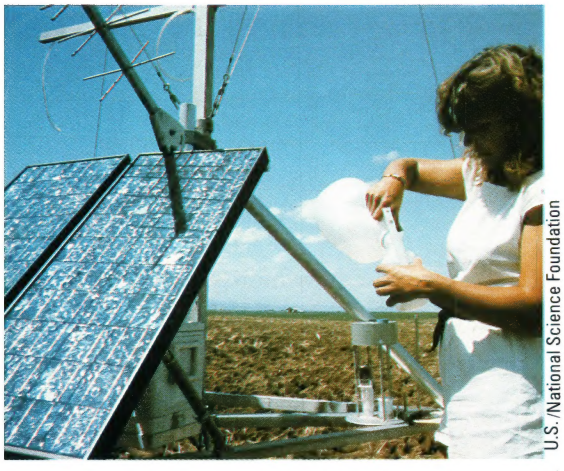


Jerry Mason/SPL

Satellite pictures can be used, along with radar observations, to make a picture of the weather systems over a large area. The two forms of data are merged in a computer that presents the results on screen as they happen – 'in real time'. These pictures are often used to illustrate the weather forecast on TV. They are also used by the TV weathermen themselves to up-date their forecasts as necessary. Satellite pictures of weather systems are very easy to interpret. A knot of clouds means a storm, and a careful look often reveals a cold front.



Chris Lyon



U.S./National Science Foundation

Photovoltaic cell panels, *which convert sunlight into energy, are used to power some ground stations. They even work in northern latitudes.*

This is where the jet streams blow from west to east at speeds up to 300 km/h. Changes in a jet stream trigger major weather changes. As an example, it was a very fast jet stream that caused the 1987 hurricane-force winds in southern Britain and western France. To observe these changes, many aircraft are now being fitted with automatic instrument packages that collect and report back temperature, wind speed and direction, wind turbulence and the plane's position and height.

The data are transmitted automatically every hour to a weather centre via communications satellites. The system, called Aircraft to Satellite Data Relay (ASDAR), is providing weather forecasters with much valuable information about the upper atmosphere. The system is also able to make readings as a plane climbs or descends, filling out the picture sent back by radiosounds.

Satellites

Satellites have made a dramatic impact on weather forecasting because they can send back large enough pictures of cloud formations to show complete weather systems. A sequence of pictures taken at different times enables forecasters to see how weather systems are moving and developing.

Currently, two sorts of meteorological satellite are used. Geostationary satellites, such as the Meteosat series, cover about a fifth of the world's surface on a permanent basis. Polar orbiting satellites, such as the Tiros series, send back data from narrow strips of land from north pole to south pole.

The troposphere *is the scene of most of our weather. Data is collected by satellite, ground stations, buoys, oil rigs and balloons to be analyzed by computer.*

Sunshine recorders *focus the rays of the Sun on to a strip of paper – the length of the burn indicates the hours of sunshine.*

Casella

Satellites carry radiometers to measure electromagnetic radiation. This radiation comprises visible light, infra-red (heat) radiation and microwave radiation. They also use infra-red techniques to make assessments of temperature and humidity at various levels in the atmosphere.

Satellites are particularly important to weather forecasters because they provide information from areas where balloon coverage is poor. The information gathered by satellite is relayed back to ground receiving stations for analysis.

Accurate forecasts

Some countries maintain a network of weather radar stations. These give an accurate – and instantaneous – picture of how belts of rain (associated with warm and cold fronts) are moving across country. With this information, forecasters can compile accurate short-range forecasts. Such forecasts have a very practical purpose. They can, for example, influence whether or not a local council will salt the roads to prevent ice forming.

A worldwide network of meteorological communications centres are linked by very fast telecommunications circuits so they can exchange these vast amounts of coded data quickly. There is so much data to process that it can only be done by the most powerful computers.

Weather forecasting systems are based on computer programs that are mathematical 'models' of the way the weather works. These use the synoptic readings taken at 00.00 UTC and 12.00 UTC to determine the current situation. The model is then used to forecast the weather situation as it will be minutes, hours and days ahead using equations developed by expert meteorologists.

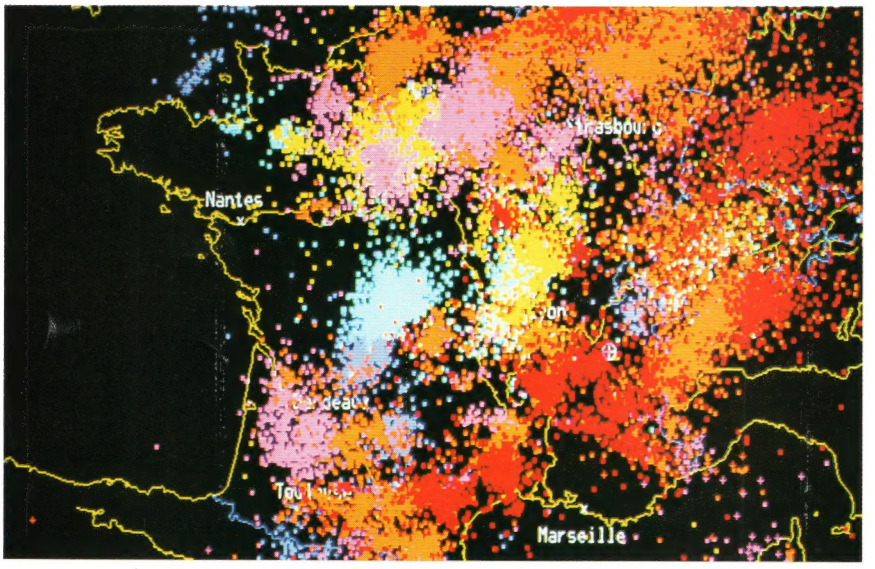
Computer charts

One mathematical model running on the COSMOS computing system works out the weather for all the points on an imaginary grid, with points spaced about 150 km apart at ground level. It also works out the weather for 15 heights in the atmosphere above each grid point using radiosonde and aircraft data.

Meteorologists add any other information they think appropriate from other sources such as satellite observations and aircraft readings. The information is then presented on charts drawn by the computer. These charts show the atmospheric pressure at different levels of the atmosphere, and are worked out up to six days ahead.

At the end of the computer run, charts and forecasts are examined by a human meteorologist who interprets the information in the light of experience. He or she also takes local geographical features such as mountain ranges and low lying land into account because these can make the difference between low cloud and rain.

After all this mighty number crunching and analysis, the forecasts and charts are made available to TV and radio stations, airports, public services, police, local authorities, motoring organizations and anyone else who needs them for commercial purposes and is therefore prepared to pay for them. For some users, specialized forecasts are prepared and tailored to their needs.



Ivaldi/Jerrican

Satellite data *relayed back to Earth is recorded on magnetic tape. Computers process the data and draw up maps showing features that meteorologists wish to study. The dots on this map represent lightning strikes and give a picture of low-altitude electrical activity.*

ELECTRONIC BUOYS

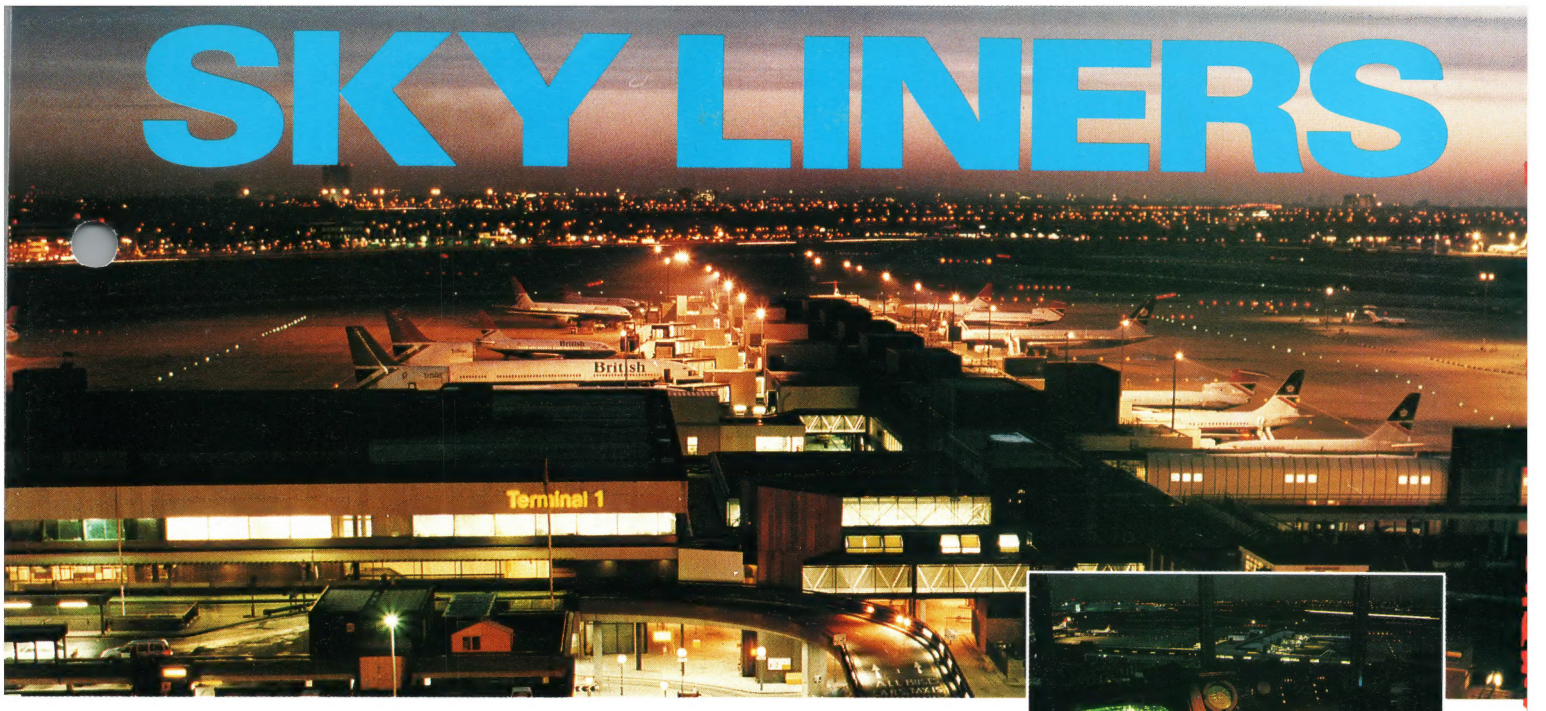
Marex

Weather buoys were developed for studying both weather and sea conditions in the North Sea during the exploration stage of North Sea oil. The basic buoy – a steel drum about 2 metres across and 1 metre deep – is divided into waterproof compartments containing the micro-computer, the radio transmitter and the batteries.

As well as standard weather observations, weather buoys can be used to measure wave height and currents within the sea itself. The top of the drum carries a mast about 5 metres high, which supports the main meteorological sensors. The sensors for sea conditions are attached to the mooring cable. Weather buoys can transmit data back to a computerized shore station for up to one year before the batteries and transmitters need servicing. Buoys are normally anchored in shallow water, close to the coast, but deep water versions are also used.

COSMOS, *the computer-based forecasting system, processes 3½ million numbers every time it draws a map of the atmosphere. As each number involves several calculations, the computing capacity required is phenomenal.*

SKY LINERS



Heathrow Visions

The Visual Control Room *(inset above) has ground movement radar (large screen) and a distance-from-touchdown indicator (small screen) to aid safe landings at Heathrow (top).*

- AIR TRAFFIC
- LANDING SYSTEMS
- SPACE PLANES

THE WORLD'S BUSIEST airports each handle over 1,000 aircraft take-offs and landings per day at the height of the holiday season. This can mean that over 100,000 passengers have to be guided safely, quickly and without annoyance through the airport during the course of a day.

An outbound aircraft comes under the control tower's surveillance even before it has started its engines. Permission to start engines is requested by radio from the Ground Movement Planner, who can observe the movements of all aircraft and vehicles at the airport from the Visual Control Room in the tower. He is assisted by ground movement radar, which displays a screen image so detailed that he can even see abandoned rubbish lying around the airfield.

Permission to take off comes from a different authority – Airfield Control, also located in the Visual Control Room. Once in the air, the plane is guided towards the airway, or air lane, along which it will fly. As the plane leaves the terminal control area, control is passed on yet again to the neighbouring region's Air Traffic Control.

One way traffic

The airways are like motorways in the sky, 16 km wide and extending from about 1.5 km to 7.5 km high. Streams of planes fly along each airway in one direction only. Aircraft at the same height are separated by at least 9 km horizontally. If they are separated by less than this horizontally, they must be at least 300 metres apart vertically.

At peak times, a plane wanting to land may have to wait in the stack – a series of circling flight paths near a radio beacon some kilometres from the airfield. The levels of the stack are spaced at least 305 metres apart. The aircraft descends in the stack until it can eventually come in to land. When it is lined up to land, about 10 km from touchdown, control is passed to the Air Arrivals Controller in the Visual Control Room. During its descent, the aircraft is kept on course by the instrument landing system (ILS), which uses two radio beams. The localizer beam extends along the centre line of the runway – to a distance of 40 km in the case of London Heathrow. The glideslope beam helps the pilot bring the plane down at the correct angle. When the weather is clear, he can also see carefully angled lights beside the runway that change appearance if his angle of approach is incorrect.

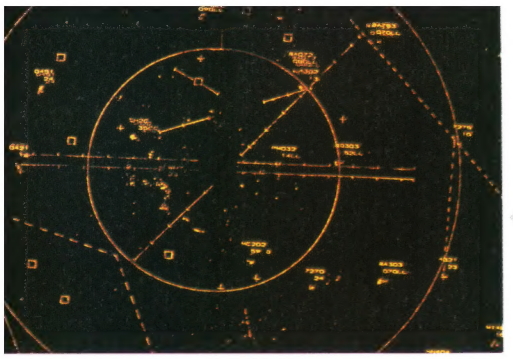
Heathrow Visions Picture Library

Good communications *with the air traffic controllers are essential for safety in busy airspace around London's Heathrow. Direct radio communications allow contact with aircraft, emergency services and airport vehicles. Controllers can speak to aircraft and vehicles on different radio frequencies at the same time.*

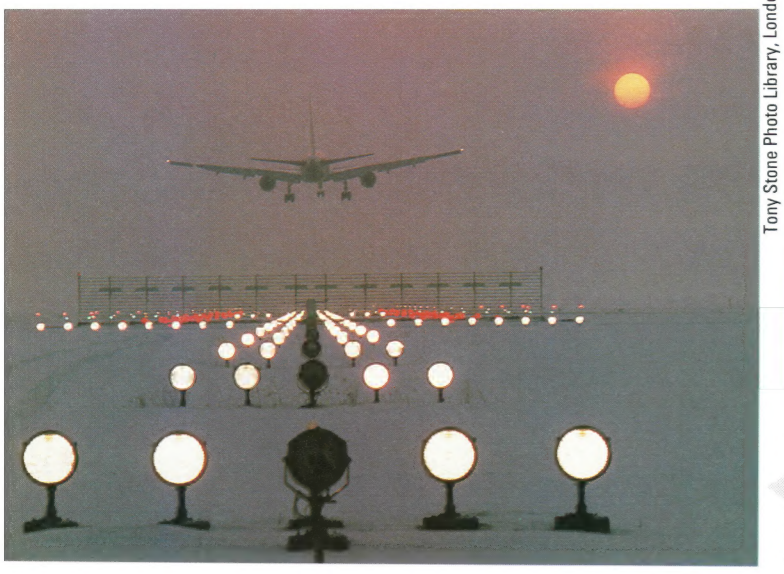
Radar displays

The skies are scanned by two main types of radar. Primary radar sends out ultra-high-frequency radio pulses that bounce off aircraft. The reflected radar signal is picked up by the radar antenna. The direction of this echo and its delay in returning reveal the position of the aircraft, which is shown as a 'blip' on the radar's display screen.

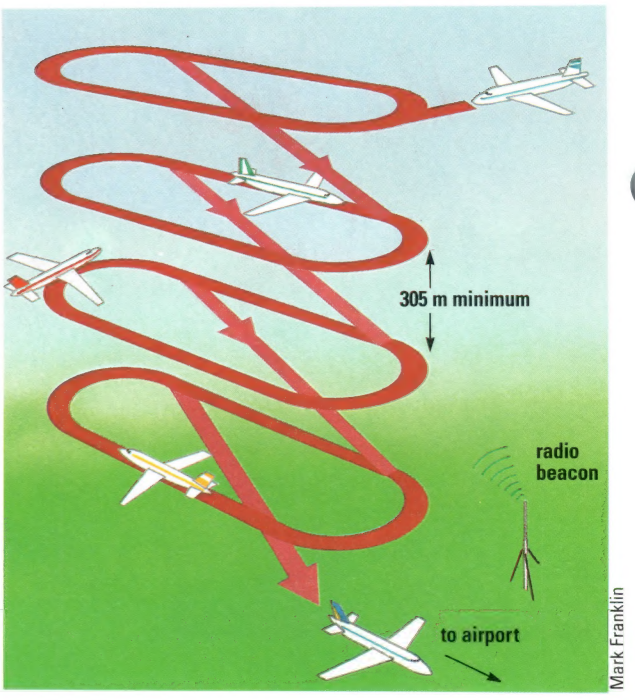
Secondary radar also sweeps the sky with a radio beam that triggers a device on the aircraft called a transponder. This instantly sends out a radio pulse with coded in-



The radar display *used by air traffic controllers shows aircraft positions and movements. Planes transmit identification signals; a computer converts these into callsigns that are displayed on screen to identify each blip.*



Tony Stone Photo Library, London



Mark Franklin

Lights and radio beams *help the pilot approach the runway from the correct direction and at the right angle as he brings the aircraft in to land at major airports.*

Aircraft wait *in a stack in an area marked by a radio beacon. When a runway becomes free, the bottom plane lands and the rest move down the stack.*

Heathrow Visions Picture Library

formation. The radar aerial picks up this signal, and the blip on the display is labelled with the aircraft's callsign. If there is some kind of emergency on board, such as a hijack, the pilot can press a button so that a warning message to that effect is also displayed on the Air Traffic Control radar.

Passenger flow

Imagine the problem of dealing with the passengers from ten jumbo jets that arrive at an air terminal in a half-hour period. That's not an unusual load – yet it can mean that about 4,000 people have to be reunited with their baggage and processed smoothly through customs formalities and immigration checks.

There must also be room at the airport for the friends and relatives who've come to greet passengers or see them off. New airport handling facilities, like those operating at New York's Kennedy International Airport, aim at processing an amazing 6,000 passengers an hour.

Airport design

Another problem faced by all airports is how to spare passengers long walks to or from the plane. A parked jumbo jet takes up a bay about 90 metres wide. If a dozen of these planes were parked side by side, passengers would have to walk over one kilometre to get to the furthest one.

Moving walkways

Airports are carefully designed to reduce this problem. In many cases, aircraft berths are arranged along piers that stick out like spokes from a hub that contains a departure lounge. Even so, moving walkways are standard in many airports now. Other 'people movers' include slow, constantly moving 'trains' that travellers step on to and off again. Another solution is to park aircraft out on the apron, well away from buildings, and take the passengers out to them in comfortable mobile lounges.

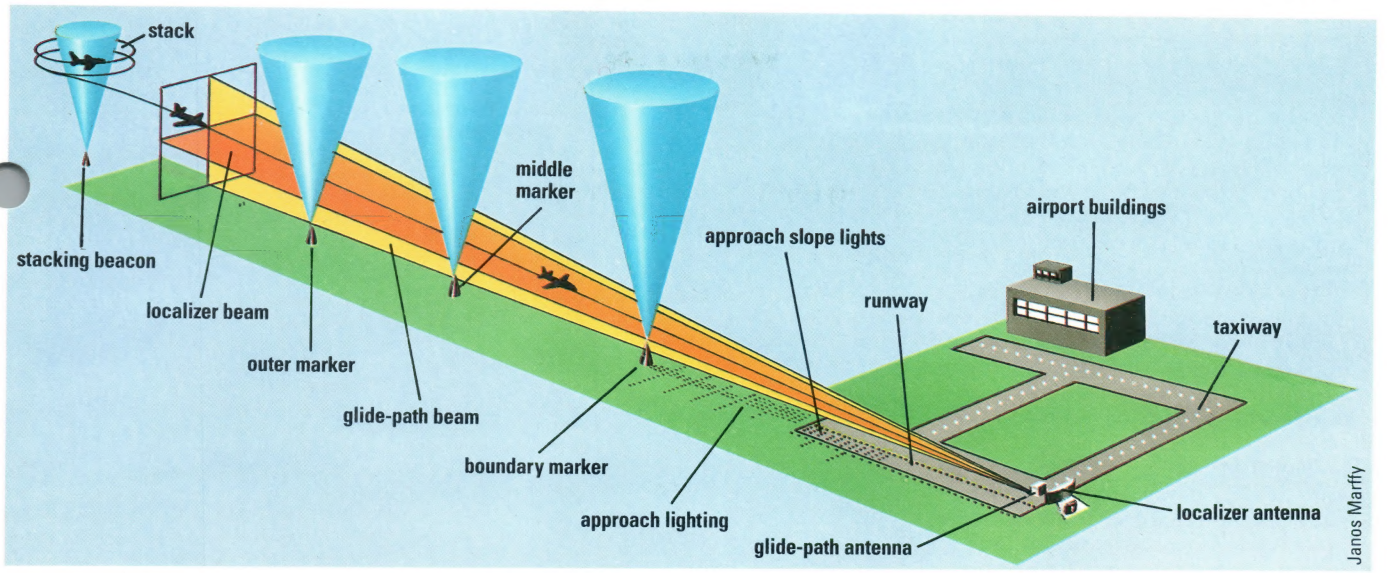
The movement of baggage is more highly automated. At the check-in counter, the baggage is weighed and tagged so that it will find its way on to the same plane as its owners, and will be reunited with them at their destination. It is carried on conveyor belts to a baggage loading point where it is packed into containers that can be loaded straight on to the aircraft.

Electronic scanning

In advanced modern systems, baggage tags are electronically scanned and the bags are automatically sorted and despatched to the right destination. In some airports, the bags are moved by robot tractors, which are called DCVs (destination-coded vehicles).

London's Heathrow *is the world's busiest international airport, with over 300,000 landings or take-offs each year, involving over 30 million passengers and some 600,000 tonnes of goods.*

Heathrow Visions Picture Library



Janos Marffy

Radio beams *from two antennae guide planes leaving the stack on to the correct approach path to the runway. Marker beams along the approach path tell the pilot how far the plane is from the runway.*

A topless Boeing *737 lands at Hawaii, its cracked and corroded roof having been ripped off during the flight. Only one person died, but 56 passengers were injured in this freak accident.*

Robert Nichols/Black Star/Colorific!

In the future the problems will be intensified by the efforts of airports to increase their plane-handling capacity. Improved methods of air traffic control will permit them to bring aircraft in safely with smaller separations, and even to use parallel or converging runways simultaneously.

This will mean a corresponding speed-up in passenger handling. Passengers won't have to wait so long for bags if plane cabins are redesigned to allow them to take more in with them as hand baggage; in addition machine-readable documents will speed up checks.

Passengers infuriated by long delays in overcrowded departure lounges often accuse airport authorities of treating them like cattle. Actually, cattle, cats and koalas are considerably better treated at some airports. Frankfurt, for example, is very proud of its animal station – a special facility for animals in transit. It can cope with animals and birds of all sizes. There are 12 boxes for large animals and adjacent sand-filled runs in which they can exercise. Eight large quarantine cells are available for isolating animals until they can be certified free of disease by a veterinary surgeon.

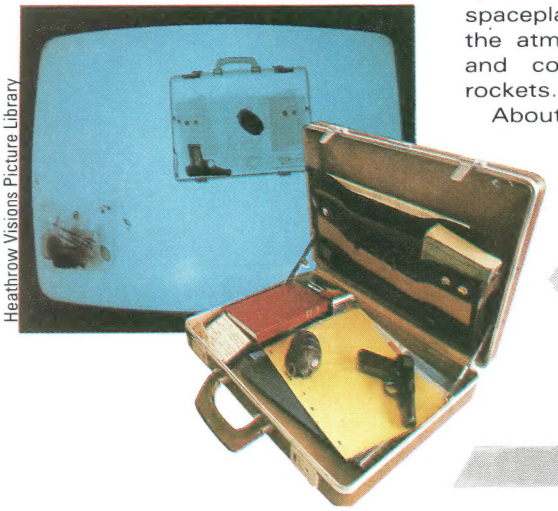
Their waste is heat-treated to disinfect it, and the air is filtered before it is discharged to the atmosphere. There are also eight dog kennels with insulated floors to make sure that the occupants don't catch chills. A vet is always on hand and various kinds of animal food are prepared in a well-equipped kitchen.

Hypersonic airliners

Work is already well under way on the hypersonic airliner of the future. When it arrives it will have a distinct resemblance to a space rocket. The technology that will enable it to cruise at more than three times the speed of sound will also be used in spaceplanes that can climb through the atmosphere using jet engines and continue into space using rockets.

About 80 per cent of the weight

Paul Raymonde

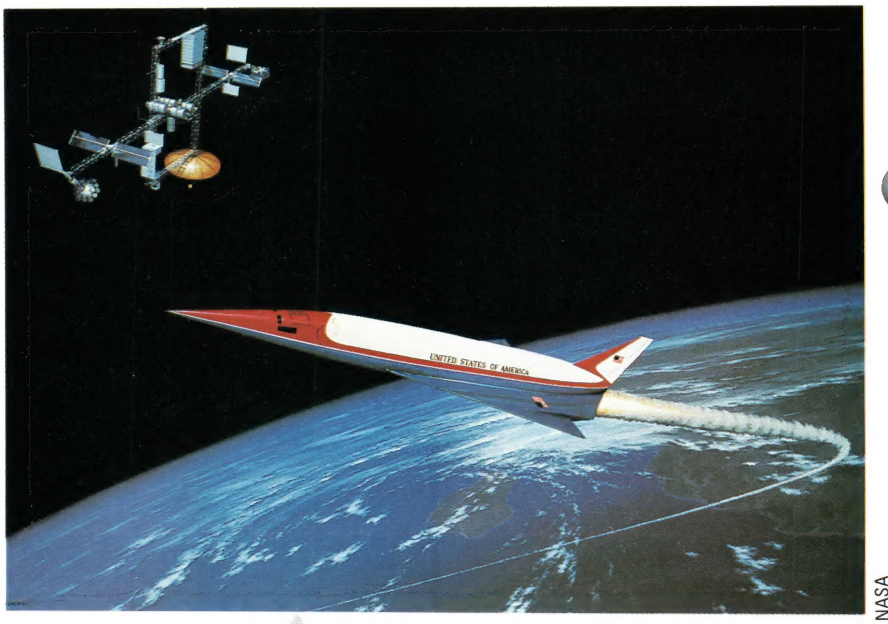


Heathrow Visions Picture Library

The danger of terrorism *on international flights is an increasing menace, so it is essential to check baggage with an x-ray machine. Guns, grenades and other metallic objects are easily spotted on the screen when the baggage passes through the machine on a conveyor belt.*

of a Space Shuttle's propellants consists of liquid oxygen, which is needed to burn the liquid hydrogen fuel. A spaceplane will be able to use the oxygen in the thin air at high altitudes, so it will need to carry much less oxygen. This technique could cut the costs of launching a satellite in low Earth orbit – say, 300 km high – to a fifth of what they are today.

The USA has dubbed its proposed hypersonic airliner the Orient Express, since Japan will be an important destination for American travellers. It is pressing ahead with a research aircraft called NASP, the National Aerospace Plane, an early version of which will fly in the mid-1990s. In one proposed design, NASP will have three engines – two quite different sorts of jet and a rocket. A turbojet will be used for take-off and for flight up to speeds of Mach 2–3. A turbojet has a fast-spinning turbine that compresses the intake air to make fuel burn well.



NASA

Heathrow Visions Picture Library

NASA's hypersonic *aircraft will take off from ordinary airport runways to reach the other side of the world within two hours. It will also fly directly into Earth orbit to take men or materials to space stations.*

Helicopters fly low *to avoid interfering with the much faster conventional aircraft at higher altitudes. Over large towns, helicopters usually have to fly along rivers or over parkland to keep clear of buildings.*

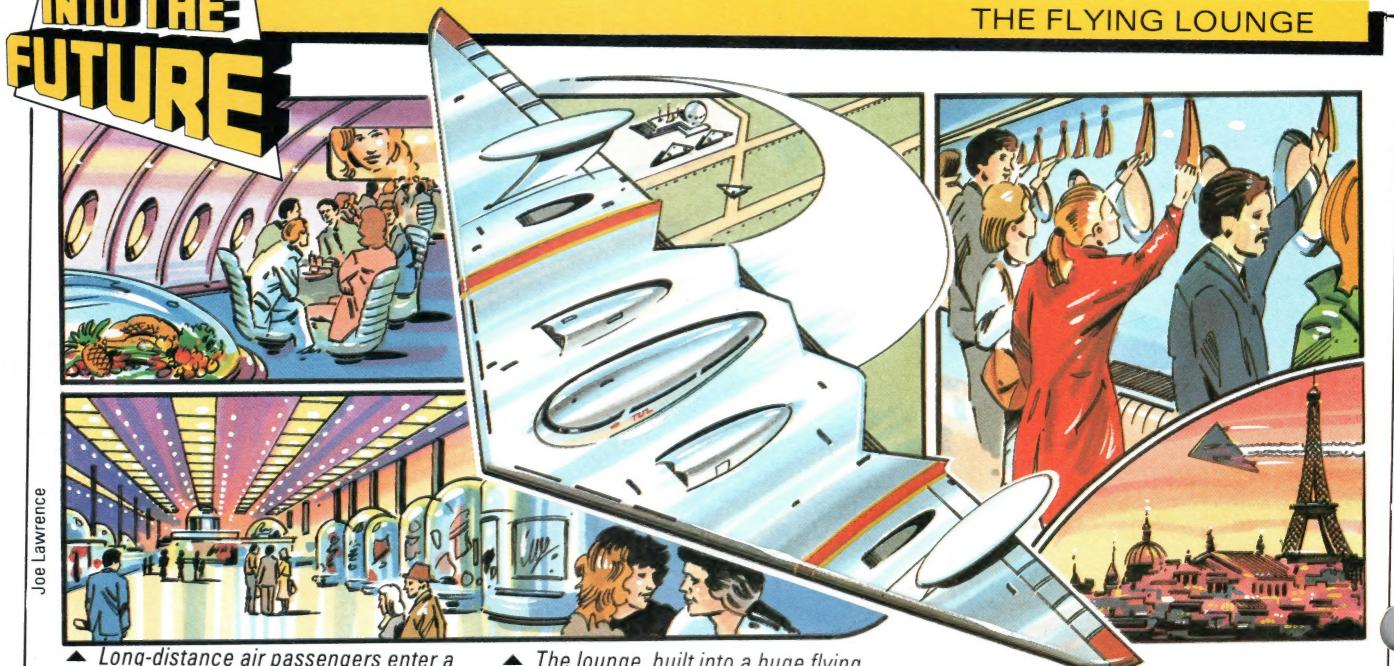
Scramjet

At higher speeds, the intake air would be diverted into the other engine. This will be a hydrogen-burning scramjet – a supersonic combustion ramjet. A ramjet has no moving parts. It relies on the aircraft's high forward speed to ram air into it and compress it.

The French AGV (*Avion à Grande Vitesse*) is planned for about the year 2010. It is designed to fly 150 passengers from Paris to Tokyo or Los Angeles in three hours. The German Sanger II vehicle will be able to carry 250 passengers on a 15,000 km journey.

INTO THE FUTURE

THE FLYING LOUNGE



Joe Lawrence

▲ *Long-distance air passengers enter a lounge, put their bulky luggage into lockers and relax over a meal, watch a video or go shopping.*

▲ *The lounge, built into a huge flying wing aircraft, takes off. Smooth acceleration and efficient stabilizers make it unnecessary to be strapped in.*

▲ *On very short trips, such as London to Paris, most passengers stand, holding on to ceiling straps.*

HIGH-TECH ARTICS

- DISC BRAKES
- GLASS FIBRE SPRINGS
- ENERGY ABSORBERS

WHEN A DRIVER CLIMBS INTO the cab of his giant articulated truck, he enters a home from home – and that's just what he needs, whether he's crossing a continent or spending a week away from home picking up and dropping loads all over the country.

These sleeper cabs are equipped with one or two bunks behind the seats, a wardrobe, cooking facilities and an independent heater for use at night. The heaters are fed with diesel from the main tank but do not burn the fuel; instead, the fuel is turned into heat with a catalyst, for safety reasons.

The driver's work load is very tiring because juggernaut trucks have up to 18 gears, which have to be matched to engine speed, the gradient of the road and the load on board. To reduce the amount of work the driver has to do and achieve more accurate use of the gears, an increasing number of trucks are fitted with pneumatically-assisted and computer-controlled gearboxes. The driver selects a gear by moving a small gearstick. He starts and stops using the clutch in the normal way, but for all other gear changes, the gears and clutch are operated automatically using air-power. In addition, the computer signals to the driver when to change gear.

***Articulated trucks** (or 'artics') of the year 2000 will be highly aerodynamic: the cab and the trailer wheels will be blended into the bodywork.*

Renault Véhicules Industriels

Hard ride

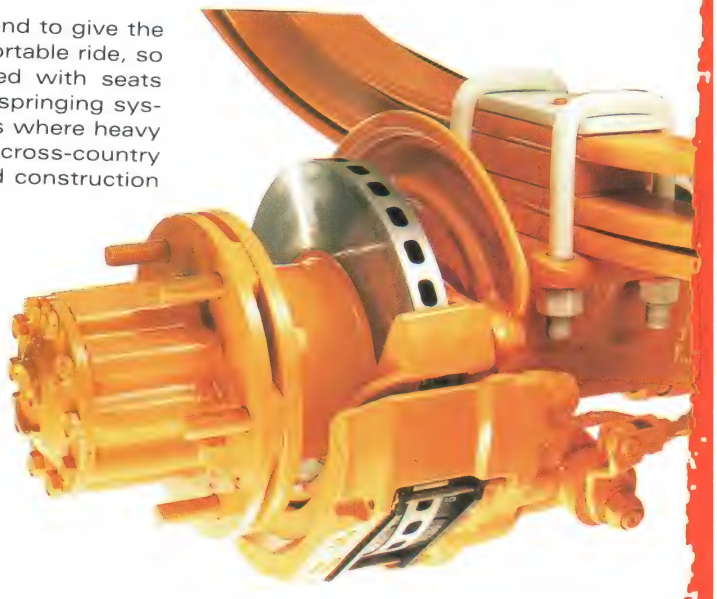
Truck suspensions tend to give the driver a very uncomfortable ride, so many trucks are fitted with seats that have a separate springing system. In extreme cases where heavy duty trucks are used cross-country for oil exploration and construction work, drivers could not keep control without a suspension seat.

Better still, more trucks will be fitted with cabs that are separate from the rest of the vehicle. Hydraulic cushions can be fitted between cab and chassis to damp out shocks transmitted from the road.

Better brakes

Disc brakes are now being fitted to more and more trucks. These stop a loaded lorry much more quickly than drum brakes and cost less to maintain. What is more, disc brakes are self-adjusting so they always work at maximum efficiency.

In mountainous countries, where a driver often needs to keep the



***Disc brakes** will be fitted to the trucks of the future. All brakes heat up rapidly when used, but air circulates freely round a disc keeping it cool and, therefore, more efficient. Maintenance is easy because there is nothing covering the mechanism.*

Iveco Ford (Truck) Ltd

Just amazing!

JUMBO LOAD

IT WOULD TAKE 300 SMALL FAMILY HATCHBACKS, MAKING A QUEUE MORE THAN 1 KM LONG, TO CARRY AWAY THE GOODS DELIVERED TO YOUR LOCAL SUPERMARKET IN ONE 12 METRE JUGGERNAUT.

Paul Raymonde

GKN plc

Cummins Engine Co Ltd

***Test rigs** are designed to reproduce the sort of stresses that a component will be subjected to while it is in daily use. These can be visualized on a video screen (above), but there is no substitute for a real life situation.*

CONTROL CRUNCH

Transport & Road Research Laboratory

Trucks are involved in fewer accidents per vehicle-km than other vehicles. But when an accident happens, trucks are lethal because they are so much heavier than anything else on the road.

Trucks are already fitted with guards at the rear, to stop smaller vehicles disappearing underneath the juggernaut. They also have side guards, which reduce the chance of a cyclist or motor cyclist rolling beneath the truck in an accident. These barriers are fixed at present, but in the future they will be fitted with energy-absorbing struts (arrowed above) so other road-users have more chance of survival.

Another safety problem is the curtain of spray thrown up by heavy trucks on wet roads. Special materials, such as 'artificial grass', are fitted inside the wheel-arches to suppress the spray but this is only partly effective. Shaping the truck body to control the airflow combined with full enclosure by side skirts will give better results by the year 2000.

brakes on for 10 or 15 km, the main braking system is often aided by an exhaust brake. In this system, the exhaust is partly blocked when a control on the dashboard is operated. When going downhill, the engine is left in gear and the blocked exhaust multiplies the engine braking effect.

At the moment, some passenger coaches are fitted with electric brakes or 'retarders'. The braking effect is produced by electromagnets mounted on the end of the gearbox, so electric brakes can be used for long distances without overheating. The brakes are regulated from the dashboard and the amount of braking can be controlled accurately, unlike an exhaust brake, which is either on or off. Electric brakes also save a lot of wear and tear on the main braking system. By the year 2000, truck maintenance will be so expensive that the extra cost of a retarder will be a worthwhile investment for long distance operators.

Juggernaut trucks will look smoother and more stylish in AD 2000. They will certainly be more aerodynamic and will weigh much less when empty. The main trends are that:

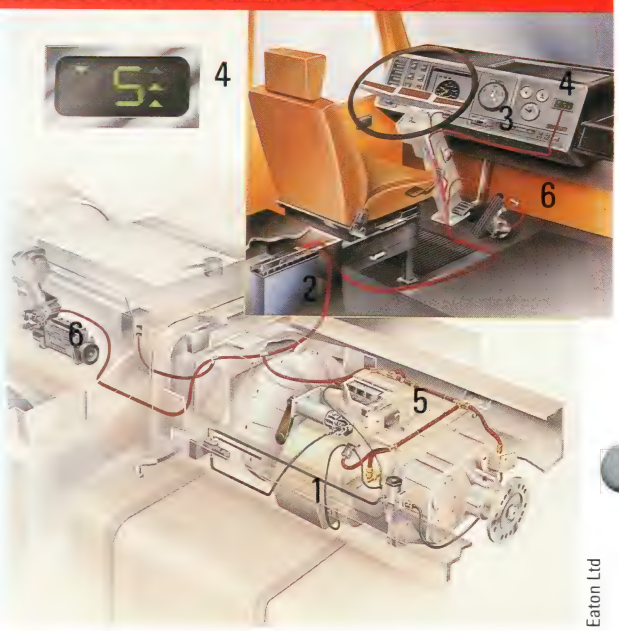
- Fewer trucks will be needed, but each one will carry more freight.
- Less steel and more lightweight metals, plastics and composites will go into their construction, so they will be lighter when empty. This means that they will be able to carry more cargo within the maximum weight of 40 tonnes.
- They will be quieter. The current aim is a noise level of 80 decibels – about the level of 1989 cars.
- Instructions to drivers for deliveries and pick-ups, navigational information, distance covered, fuel used and expenses incurred will automatically be transmitted to and from head office via satellite.

Modern turbo-charged diesel engines and simple aerodynamic improvements like flush headlamps have already reduced the fuel consumption of a juggernaut from about ten times to about six times that of a small diesel car. The modern juggernaut is very economical to operate and is likely to become even cheaper in the future when ceramic pistons will enable engines to run much hotter.

As more and more freight traffic is transferred to the road from the railways, roads will start to break up unless this is taken into account when trucks are designed. Thus rubber and glass fibre suspensions will become standard as they can be tailored to cope with the enormous difference in weight between an empty and a loaded juggernaut.

SEMI-AUTOMATIC TRUCK TRANSMISSION

Electrical wires replace the direct mechanical controls on a semi-automatic gearbox. This is the first step towards 'drive-by-wire' and the fully electronic truck where the steering and diesel fuel pump are also computer-controlled. **1** 12-speed gearbox **2** Control computer using inputs from speedometer, throttle and gearbox **3** Gear selector close to steering wheel **4** Dashboard display **5** Air-powered gear changers taking signals from control computer (2). **6** Electrical throttle control.



Eaton Ltd

- STEEL SKELETONS
- DIZZYING HEIGHTS
- SWAY FACTOR

SKY HIGH

THE SKYSCRAPER FOREST that is New York's Manhattan would be impossible to re-create in London. This is because Manhattan Island is one huge chunk of granite, whereas London is built on a bed of clay and is scarcely capable of sustaining a building of more than 60 storeys.

Spectrum Colour Library

***A grid of skyscrapers** in Toronto, Canada, creates wind tunnels. At 553 metres, the CN Tower (right) – the world's tallest freestanding structure – can sway 2 metres.*

Weight is a prime problem in the construction of high buildings. The stress on the lower sections of a very tall building is only slightly less than the stress on the foundations. For this reason, the top section of a skyscraper must be made of lighter materials. Most multi-storey buildings have a frame which is usually made from steel girders that become thinner and lighter towards the top.

Swaying in wind

One of the other great strains a tall structure has to take is the bending moment – the leverage force exerted on the base when winds strike the top. As a rule, the taller a building, the beefier its base.

Winds buffeting the top of a 100-storey building are four times as strong as those hitting a 50 storey building. A hurricane can exert 4,000 tonnes of pressure against the side of a very tall skyscraper!

Wind vibration of a building can have drastic consequences, particularly the frequent, intermittent gusts that arise when winds are forced down narrow street networks between skyscrapers. Like any other structure, a building has what is called a 'natural frequency'. This is a vibrating frequency at which the structure will begin to vibrate with

greater motion than the force which caused it to start moving. The vibrations increase in intensity until they shake the structure to pieces.

To counteract wind-induced motion, huge weights can be mounted on rails near the top of a skyscraper. As the building moves, the weights start to move too. Because they are still moving in the original direction when the building sways back, they act as a counterbalance – killing the swing.

Winds also pose a hazard at street level. Buffeting gusts can sweep pedestrians off their feet. This is a regrettable (but unavoidable) consequence of a skyscraper city. However, if winds get into a tall building at ground level they can travel upwards via the lift shaft and can do great damage. On many tall buildings, the lift shafts are staggered – you have to change elevators half way up to get to the top – to avoid this ever happening.

George Wimpey PLC

A temple of steel *to modern finance, the building of the headquarters of the Hong Kong and Shanghai Banking Corporation. Like a lobster, it wears its 'skeleton' on the outside, proudly showing off its main structural features. High rise living and low cost sampans (below) are a feature of crowded Hong Kong.*

Tony Stone Photo Library, London

Safety

How do engineers design skyscrapers so they are strong enough to withstand the various stresses they have to endure? A great number of calculations can now be made from computer simulations. The strengths of materials and different structures made from them can be programmed into a computer, as can forces, such as gravity and wind pressure. The building is then designed on the screen and the computer predicts whether it will stand up and in what conditions it will remain standing.

Any building must always have an element of redundancy – that is, more structural strength than it needs in order to withstand the greatest forces it will ever have to face. Early skyscrapers had a great deal more redundancy than the buildings of today. For instance, the Empire State Building, erected in New York in 1931 to a height of 381 metres, has a greater weight of steel per metre than the much taller 412-metre, twin-towered World Trade Centre built in the city in 1973.

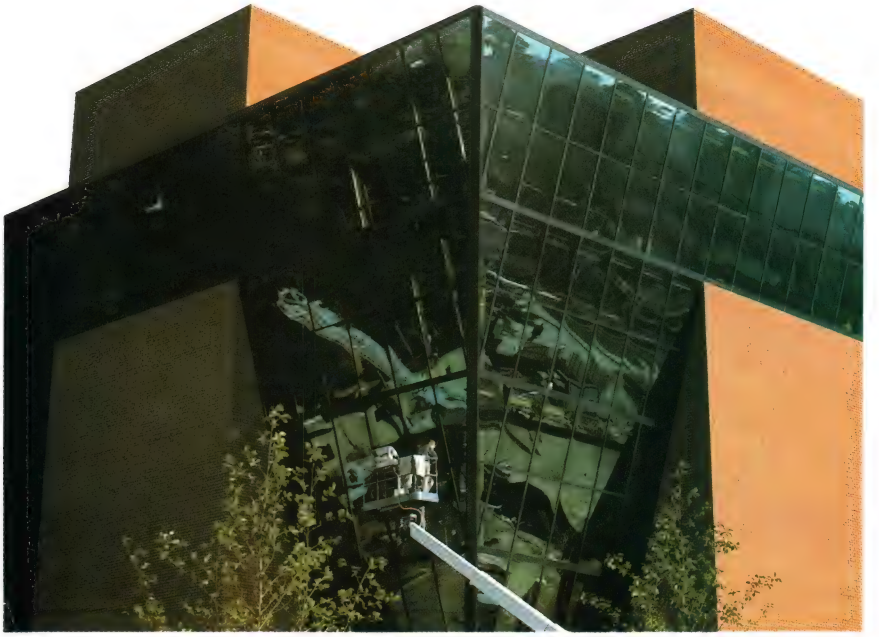
Better understanding of how buildings react to the strongest gales, plus the development of high strength steels and concretes, have allowed architects to design structures twice as high as existing ones.

To discover peculiar problems that may occur with particular designs, scale models are built and tested in wind tunnels. When the Chicago architect, Harry Weese, placed a 1.4 metre model of his design for a 210-storey building in a wind tunnel, the tip of the tower began to oscillate violently. In a full-scale building, this would have

▲ *With buildings planned that will reach 1.6 km into the sky, it will never be necessary for a resident to venture into the danger of the street.*

▲ *These skyscrapers will not only provide a home and workplace for their inhabitants, they will also house medical services and the shops they would need.*

▲ *They will have entertainment facilities, such as a cinema, swimming pool and even a concert hall. There will also be a heli-pad on the top of each building.*



Richard Bryant/Arcaid

It's great at the top, *if you can stand heights. Ever taller buildings require special equipment to clean their windows.*

been a round trip of more than 20 metres every minute. Only a test pilot could keep his lunch down in such conditions.

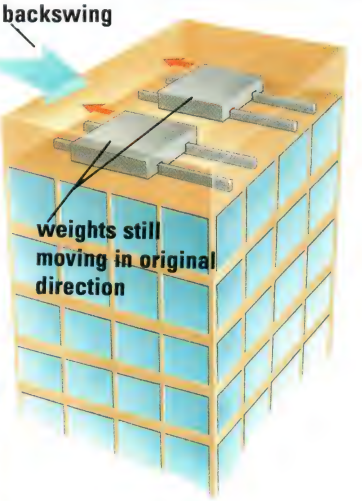
Towering infernos

Another great risk in skyscrapers is fire. There is no means of escape from tall buildings and the structures become deadly, towering infernos. Two such disasters occurred in São Paolo, Brazil, in the 1970s.

It is also essential that a tall building has the means to extinguish any fire that starts inside it. This is achieved by placing giant water tanks at the very top to supply water sprinkler systems in the ceilings of every floor. Lift doors must also close automatically, because lift shafts are a prime means of spreading fires.

The fire-fighting system has to work instantly, so it cannot rely on human activation. The sprinkler systems start automatically once smoke or heat alarms are set off. The alarms may also close off the area in which the fire starts by locking fire doors. This confines the blaze and prevents it spreading to the rest of the building.

A 'Towering Inferno' *can become a tragic reality if skyscrapers are not fully equipped for all possible emergencies – including fire.*



Chris Lyon

Large weights on rollers *at the top of a skyscraper counteract sway: they move with the building and continue in the same direction even as the building swings back, so acting as a counterbalance.*

SMASH HIT

Many windows fell out of the 60-storey John Hancock Tower in Boston, USA, in 1974 because of the 'sway factor'. If a building of that height (or higher) sways by more than a few centimetres at the top, the window frames stretch on the away swing, loosening the glass; on the back swing the reverse happens – and the glass is crushed.

Omri Eytan/Architectural Association

'intelligent' because they control their own environments and operations without requiring people to switch systems on and off.

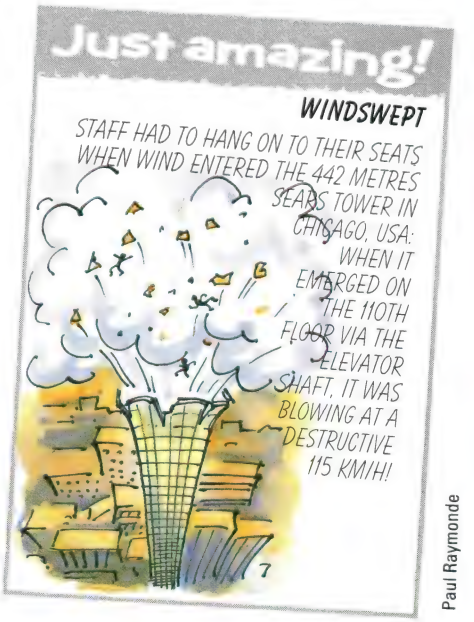
Buildings of more than 25 storeys are erected almost exclusively for offices or other commercial purposes. This makes computer control of utilities an easier task, as people tend to arrive at work and leave at roughly the same times. It is, therefore, possible to have a 24-hour cycle for, say, a heating system, so in winter it is on during office hours and off throughout the night.

Warner Bros/Kobal Collection

All these elaborate control systems depend on electrical power. If this fails for any reason, the building shuts down. There must, therefore, be an emergency generator system to carry out essential functions in the event of a power cut – to work the lifts so that people can be evacuated, for instance.

Computer control

Computers linked to sensors and timers can also control the lighting, heating and security systems of a building. Such buildings are called

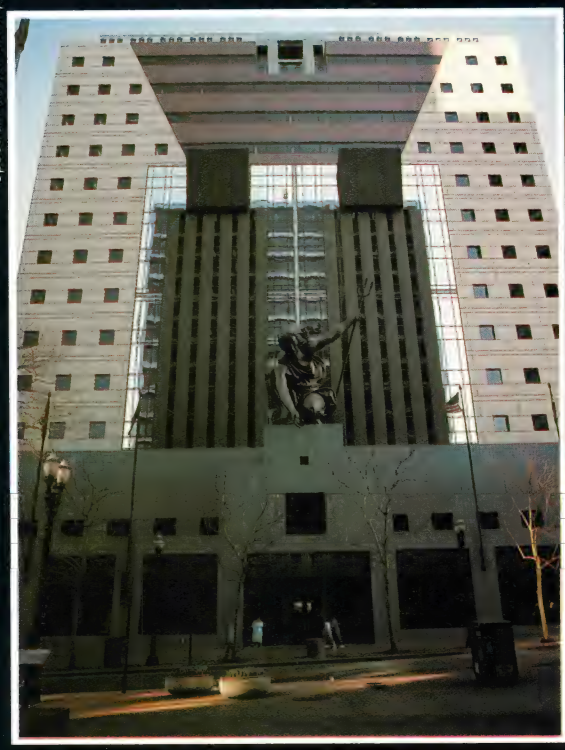


Paul Raymonde

'Inside-out' is a fair description of the Pompidou Centre, Paris. Its supporting structure, stairs and lifts are all on the outside.

Sears Tower, Chicago, is the world's largest private office building. The 110-storey tower has lifts that get to the top in about one minute.

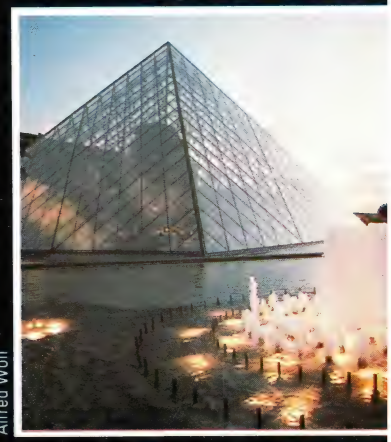
The Portland Building, Oregon, was a protest against plain office blocks. Decorative strips of mirror glass extend up the front of the building, but the tiny, bare windows of the offices make them look like cell blocks.



Spectrum Colour Library

The Opera House, Sydney, was opened in 1973, nearly 15 years after construction began, at a cost of more than £50 million. The design, by Jorn Utzon, was chosen from over 200 competition entries.

Spectrum Colour Library



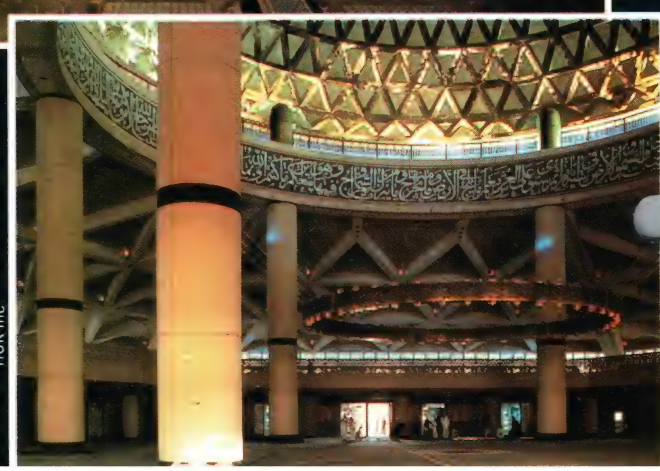
Alfred Wolf

A glass pyramid is the entrance to new galleries beneath the Louvre museum, Paris. Many dislike having such a modern structure in front of the old museum. Other people enjoy seeing the contrast between the old and the new structures.

Sears

HOK Inc

King Khaled International Airport, Riyadh, Saudi Arabia, has two international and two domestic terminals, (ornate interior, right), a Royal Terminal, a Mosque for 5,000 worshippers and a large car park that can accommodate up to 11,000 vehicles.



HOK Inc

MEGA MACHINES

- BEEFY BULLDOZERS
- STEEL SHUTTERING
- LAYING FOUNDATIONS

Property Enterprise Trusts

Cementation Piling & Foundations

Gravity-driven *pile drivers are usually fitted to bulldozers with caterpillar tracks so they can move easily around sites. The tower acts as the guide rail for a large weight which is winched up to the top of the tower, then dropped on to the pile. The impact hammers the pile into the ground.*

Each pile is positioned by a surveyor using a theodolite.

Construction sites *are crammed with machinery* ***1*** *Tower crane, inside lift shaft.* ***2*** *Steel reinforcing rods welded together to form core of concrete pillar.* ***3*** *Steel shuttering for concrete walls ready for lifting into place with crane.* ***4*** *Temporary safety rails to prevent falls.* ***5*** *Lift with steel safety cage for site workers.* ***6*** *Cement hopper.*

AS BUILDINGS GET BIGGER and bigger, so they need deeper and deeper foundations. As they get taller and taller and taller, the cranes used during construction have to be higher than ever.

On sites that have never been built on, giant bulldozers with caterpillar tracks are used to push the top soil to one side so that few plants and tree roots will be able to grow under the building and disturb the foundations. The fertile top soil is loaded into tipper trucks and transported to areas such as worked-out quarries where it can be used to rebuild the land surface. Finally the bulldozers level the site.

It is quite easy to build in cities such as Chicago and New York where solid rock lies only a few feet below the surface. But in cities such as Paris with soft clay under the surface, very tall buildings would simply sink into the ground.

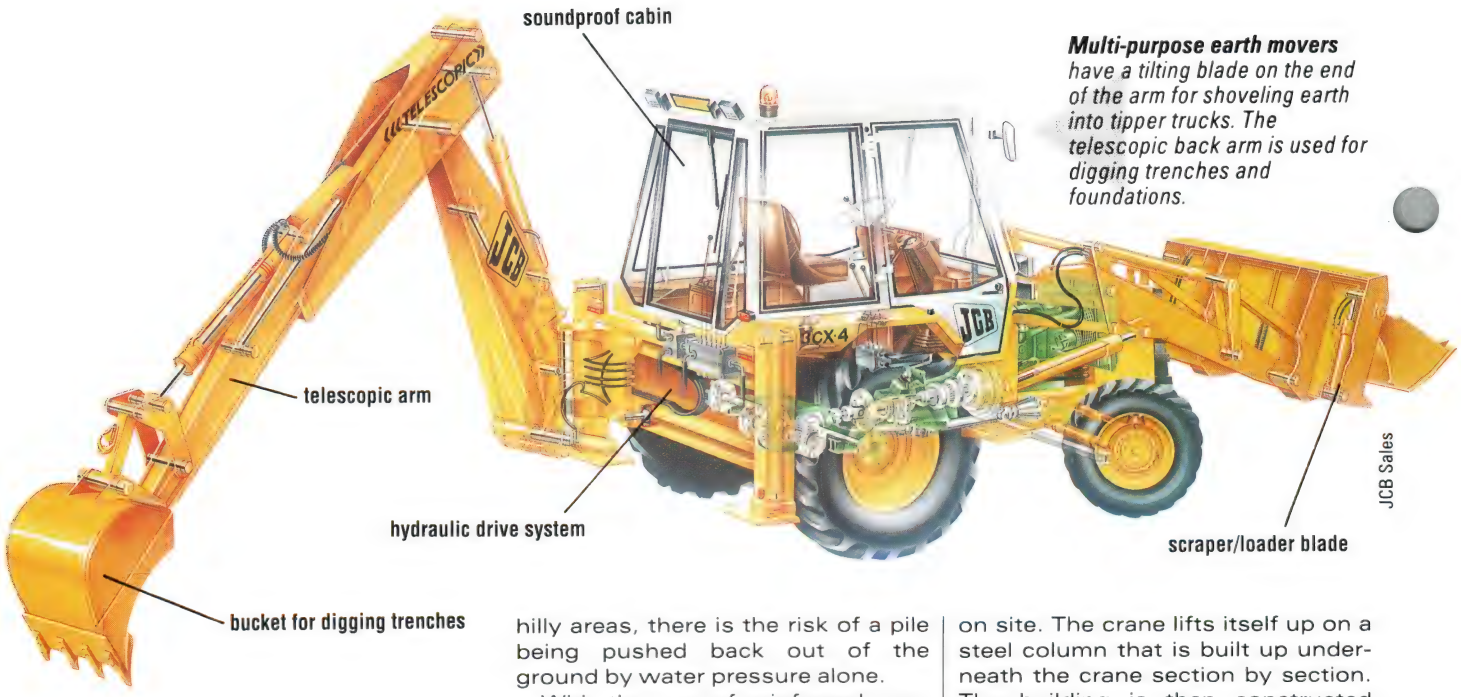
To stop this happening, the first job on many building sites is to test the soil structure using machines, shaped like giant corkscrews, that bore deep into the earth. When these tests have been completed, the site engineers start to drive large tubes into the earth. These tubes, called piles, are driven deep into the earth until they reach the firmer compressed subsoil, sometimes more than 25 metres down. Piles are usually made from concrete and/or steel, so the machines that drive them into the ground have to be very powerful.

Pile driving

Sometimes a top layer of rock or firm ground is supported by softer ground underneath and the piles have to be driven deeper and deeper until they touch bottom.

A pile driver is a very heavy hammer, sometimes driven by a built-in diesel engine. This type of pile driver is hoisted up by crane and sits on top of the pile where it jumps up and down, powered by the diesel engine, driving the pile into the ground.

For deeper work, contractors send for specialists who use gravity-powered machines. These are mounted on caterpillar tracks so that they can work in the deep mud that often covers building sites in the early stages.



Multi-purpose earth movers *have a tilting blade on the end of the arm for shoveling earth into tipper trucks. The telescopic back arm is used for digging trenches and foundations.*

In cities where high-rise buildings are close together, the vibration caused by pile driving can damage the surrounding buildings and drains. The noise is also a problem with people trying to work and live nearby. A less disruptive way of making deep foundations is to drill through the soil with giant drills or augers, which are much quieter and vibration free. If the soil is sandy, high pressure water jets can be used to wash out deep holes that are then filled with concrete. These work in the same way as piles.

Flooded foundations

On some building sites, rain water can cause flooding of the foundations. In these conditions, diesel-powered pumps are kept on stand-by twenty four hours a day to clear the water as soon as it collects. If the natural level of water in the ground is very high, particularly in hilly areas, there is the risk of a pile being pushed back out of the ground by water pressure alone.

With the use of reinforced concrete and steel girders, high-rise construction has become relatively quick. Steel girders are lifted into position by crane – and it does not necessarily matter whether the crane driver can see what he is doing. He is directed by a man on the ground who communicates through a two-way radio.

Most sites have at least one mobile telescopic crane, mounted on a lorry, that is capable of lifting 16 tonnes up to a height of 120 metres. These machines could lift an elephant up to the top of London's Canary Wharf Tower.

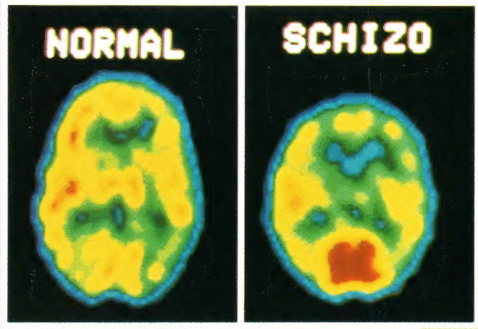
Most big construction sites also have at least one crane assembled on site. The crane lifts itself up on a steel column that is built up underneath the crane section by section. The building is then constructed around the crane, which is eventually taken to pieces and removed through what will become the lift shaft when the building has been completed.

Concrete pillars, walls and floors are cast in moveable steel or wooden moulds known as shuttering. Concrete is pumped to the top floors in large diameter flexible hoses. A powerful diaphragm pump forces the wet concrete through the hoses and up into the building.

Tower cranes *remain on site until the building is almost complete. Once the basic frame is finished, the steel cladding is quickly fixed in place using a system of steel rails.*

IMBALANCES

***Crowned** with a futuristic helmet, a patient heads for a PET (Positron Emission Tomography) scan. PET scans show how different parts of the brain work, using safe chemical tracers introduced into the body.*



US National Institute of Health/SPL

***Colour-coded images** of normal and schizoid brain PET scans show the differences in the metabolism of a glucose tracer in the brain.*

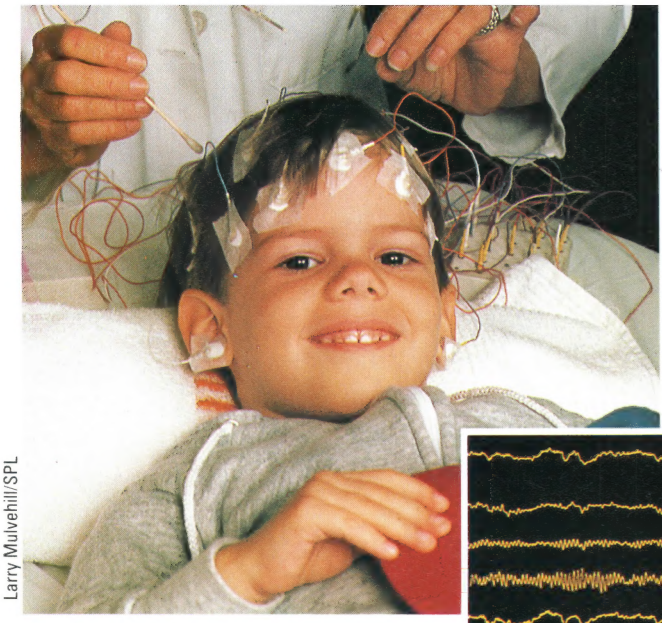
- SYNAPSES
- NATURAL DRUGS
- NEUROTRANSMITTERS

MUCH THAT WE TAKE FOR granted about ourselves – the way we feel, think, react, our very personalities – may well be the result of a delicate balance of chemicals, such as neurotransmitters, in our nervous system. These are transferred at the synapse – the meeting point of two nerve cells, or neurons.

Each neuron is a fluid-filled cell with a semi-permeable membrane. Within the fluid are electrically-charged particles (or ions) of sodium, chloride and potassium. These ions move in and out of the cell through the membrane. The movement of these positively and negatively charged ions changes the electric potential (or voltage) of the membrane, which can then create an electrical impulse.

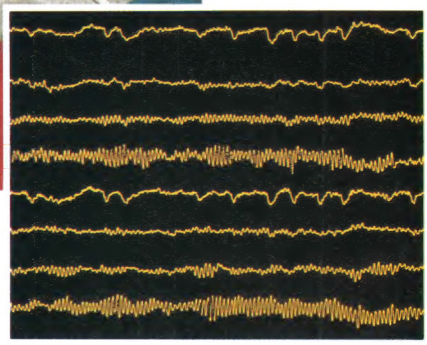
At its end, each axon (the conducting part of a neuron) divides into thousands of nerve fibres that each end in a knob – the synaptic

Roger Ressmeyer/Colorific!



Larry Mulvehill/SPL

***Electrodes** will record the electrical activity of the brain in an EEG (electroencephalogram), which will print out as waves (inset below).*



SPL

knob. The site where these knobs meet other neurons is known as a synapse.

Within each synaptic knob are vesicles, or sacs, that contain chemical substances known as neurotransmitters. There are possibly as many as 100 neurotransmitters

Neurotransmitters are either excitatory or inhibitory. Excitatory neurotransmitters let in more positively charged ions through the neuron membrane than they let out: this makes the potential of the membrane more positive. Inhibitory neurotransmitters let in more negatively charged ions, making the potential more negative. Accordingly, an impulse is either fired or suppressed in the nerve.

The electrical impulse, caused by the movement of the ions, draws the vesicles to the edge of the synaptic knob. Here, the vesicles burst open, spilling out thousands of molecules of neurotransmitters into the synaptic cleft – a microscopic space between the synaptic knob and the membrane of the receiving neuron.

The neurotransmitters from the pre-synaptic cells (the cells where the electrical impulse originated) now move on to the post-synaptic cell – the cell that receives the neurotransmitters; these then pass on the electrical impulse. When the neurotransmitters arrive at the post-synaptic cell, they spark off another electrical impulse that travels along the receiving nerve.

Until recently, only a small, select group of neurotransmitters were known, such as acetylcholine, norepinephrine, serotonin, dopamine, histamine, glutamate and gamma-aminobutyric acid (GABA) – the major inhibitory transmitter substance in the nervous system.

The discovery of many more transmitter substances, commonly grouped together under the heading neuropeptides, has expanded this list considerably. Besides being capable of selectively relaying messages between groups of cells, some of the neuropeptides can evoke quite complex responses. As an example, minute amounts of one neuropeptide, thyrotrophin-releasing hormone (TRH), can induce euphoria and could be used as an antidepressant.

The various neuropeptides known as endorphins and encephalins have pain-killing effects similar to morphine. They do this, it seems, by inhibiting neurons from relaying a message that a stimulus should be registered as pain.

Blood-brain barrier

Scientists using dyes to stain animal tissues for examination discovered that there was some sort of barrier in the brain that let through only certain substances from blood. Intravenous injections of dyes would stain all organs except the brain.

Blood capillaries in the brain appear to have a different structure to those elsewhere, so that only water, carbon dioxide and oxygen

ENDORPHINS – THE BODY'S OWN TRANQUILLIZERS

Does rigorous exercise produce its own rewards? Many regular exercisers maintain that they experience a feeling of well-being and elation, particularly during prolonged physical activity. While this may to some extent be due to feelings of self control and a sense of achievement, exercise may also be responsible for an increase in the level of neurotransmitters, such as endorphins and norepinephrine.

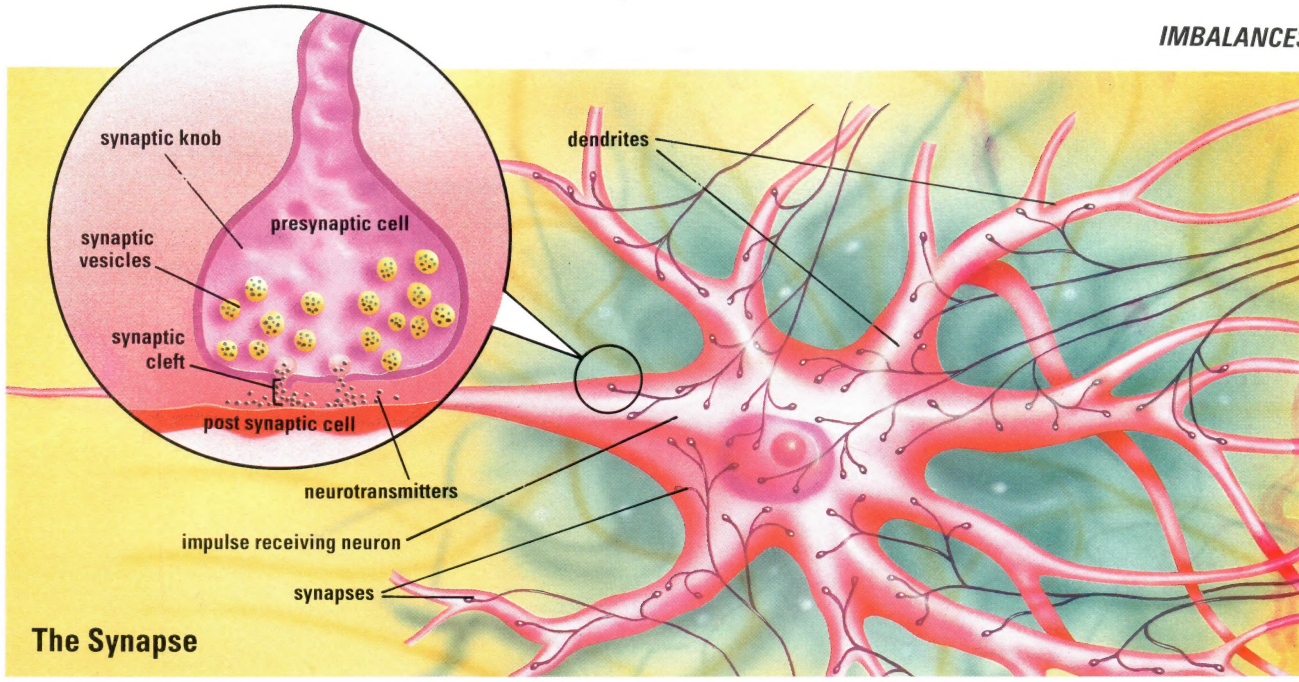
The body, under the influence of intense physical stress (such as exercise or childbirth) can produce its own tranquillizers – the endorphins – within the nervous system and elsewhere. They seem to have a pain-killing effect similar to aspirin.

But endorphins also have a part to play in pleasurable sensations and may be the key to understanding the physical origins of pleasure and pain. It seems that a repeated stimulus – as in exercising – will release endorphins, which appear as a reward to the person. This may be why runners love running – both short and long distances.

Supersport Photographs

Richard Smith

***A step at a time.** A child with cerebral palsy is taught by the 'conductive method'. This re-educates the undamaged parts of her brain to take on functions the damaged parts cannot cope with.*



The Synapse

CNRI/SPL

pass from blood to brain with ease. Many other substances are allowed no access, or only very slow passage through.

The barrier is thought to exist to protect and maintain the working of the brain, especially the neurotransmitters. This is because neurotransmitters would be that much less effective if they could diffuse throughout the body, instead of being kept relatively restricted to the central nervous system.

Mental chemistry

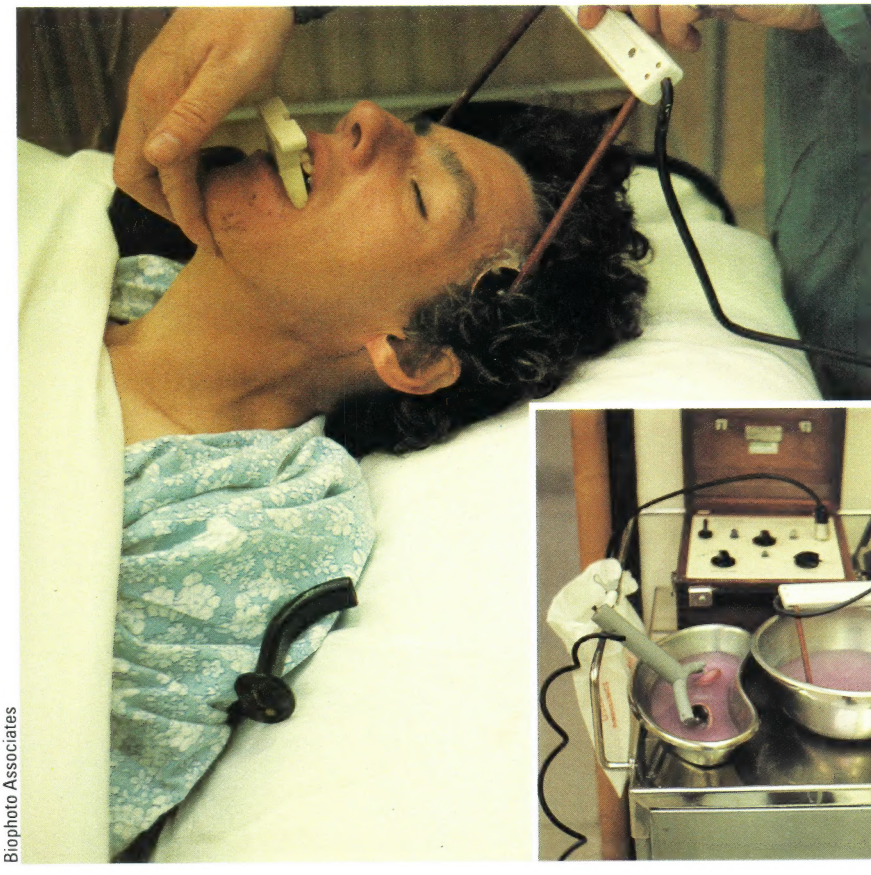
Neurotransmitters are chemicals and so also are drugs. A number of drugs are used to combat depressive illnesses. Common symptoms of such conditions are feelings of deep despondency and hopelessness. Some sufferers are known as manic depressives, since their moods also swing to elation and creativity. Drugs that increase excitatory transmitter substances in the nervous system, especially norepinephrine and serotonin, are often used to treat depression.

***The synapse** is where an electrical impulse from one nerve cell is passed on to another. The electron micrograph (right) shows the synaptic cleft as deep red and above it the vesicles (sacs) as red and yellow spheres.*

Chris Lyon

Parkinson's disease is one of the most obvious diseases related to chemical imbalances in the brain. Named after the surgeon who first described the condition in 1817, James Parkinson, the chief characteristic of the disease is a continuous and noticeable shaking of the limbs and impaired control over everyday, voluntary movements.

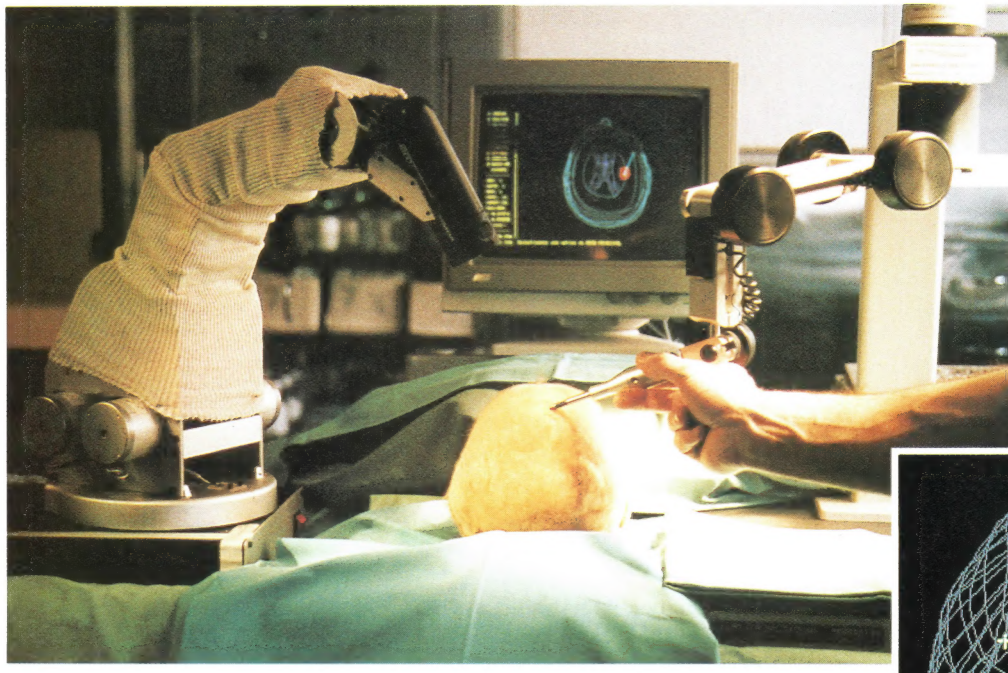
The root of the problem lies in the forebrain at the basal ganglia, where there are pathways both to and from the autonomic nervous



Biophoto Associates

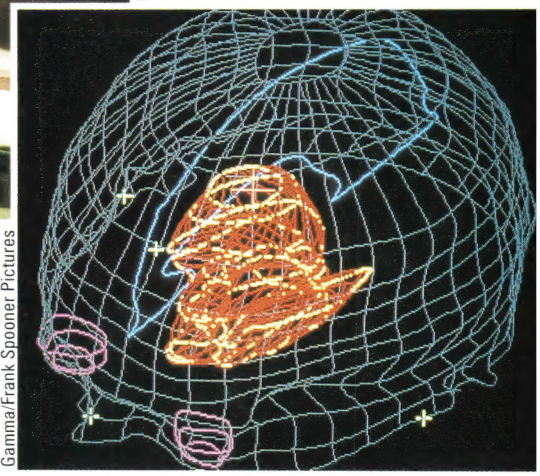
Biophoto Associates

***'Shocking treatment'** is how ECT (electro-convulsive therapy) is often thought of. It 'cures' severe depression, but the price is a loss of some memory: 70-130 volts can be applied through electrodes while the patient is fully anaesthetized.*



Gamma/Frank Spooner Pictures

Surgery by robots; *computer by man. A 3-D scanner provides a see-through image of the skull and brain (inset below). This enables doctors and surgeons to pinpoint the exact location for surgery or radiotherapy. Thanks to a micro computer, surgeons can use the image interactively to guide a surgical robot when operating on the brain.*

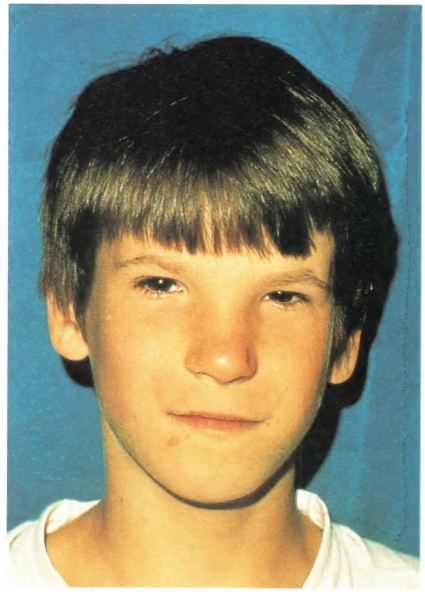


Gamma/Frank Spooner Pictures

system, the cortex and the limbic system.

The transmitter substance, dopamine, which is largely responsible for transmission of nerve impulses in this area, seems to be depleted increasingly as the disease progresses. This leads to random firing between neurons, causing unnecessary skeletal movements, for example. It has been found that injections of dopamine are quite useless, since the protective 'blood-brain barrier' does not allow the dopamine to pass to where it is needed. Drugs that increase the rate of dopamine release do help.

Scientists are hoping that foetal tissue, taken from aborted human foetuses may offer a long lasting cure. Foetal transplants involve injecting undeveloped cells into the diseased area of the brain. As they grow and mature, they produce the dopamine that the damaged cells cannot.



Prof Sterling K Clarren

Abused by alcohol before birth, *the young boy shows the flattened face symptoms of Foetal Alcohol Syndrome. Excessive alcohol can prevent the full growth of nerve cells in the foetus and can lead to a mentally handicapped baby.*

Schizophrenia is a mental disorder that, although having no clearly definable origin, does seem to have an organic cause involving neurotransmitter substances. Sufferers experience hallucinations and delusions.

Drugs that seem to be able to help cure schizophrenia are now known to block dopamine receptors in the brain.

Just amazing!

DOES IT HURT?

WHEN THEY LOST THEIR LIMBS IN WORLD WAR II, SOME SOLDIERS FELT NO PAIN FOR A WHILE – NEUROTRANSMITTERS MAY HAVE BLOCKED PAIN RECEPTORS IN THE BRAIN. THE EXCRUCIATING PAIN RETURNED LATER.

Paul Raymonde

Weidenfeld Archives

Super talented *and severely handicapped, Stephen Wiltshire produces architectural drawings of exceptional draughtsmanship. But he is also autistic. Doctors cannot explain why certain mental handicaps go hand in hand with remarkable talents in other fields.*